

DRAINAGE DEVELOPMENT, SOUTHERN SACRAMENTO MOUNTAINS, NEW MEXICO

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INTRODUCTION

Field mapping some years ago in the Surveyors Canyon area of the southern Sacramento Mountains, New Mexico, revealed an unusually well-developed set of barbed tributaries. Later visits to adjoining areas, and a study of topographic maps and air photographs, have disclosed many other evidences of stream capture and diversion. Several of these features are described in this paper, and suggestions as to the evolution of the drainage are presented.

The origin and significance of the features described have been discussed with Lloyd C. Pray and Richard P. Goldthwait, to whom I express appreciation.

GEOLOGIC SETTING

The Sacramento Mountains of south-central New Mexico are an asymmetrical north-trending fault block of Paleozoic sedimentary rocks (fig. 1), bounded on the west by a zone of normal faults. They constitute the southeasternmost unit of the Basin and Range physiographic province. The summit of the range stands some 4,300 ft above the Tularosa Basin, a large graben floored with Quaternary alluvium. Displacement on the boundary fault zone is at least 7,000 ft (Pray, 1954), and may be considerably more.

Extending southeast from the central part of the range is a zone of sharp monoclinical folding and normal faulting. This was shown by Darton (1928, pl. 44) as a continuous fault, and it has been termed the Sacramento River fault. Maximum displacement along this zone is estimated at 1,000 ft. The zone is *en echelon* with the major boundary fault of the range and with that of the Guadalupe Mountains some 25 miles to the southeast; and it shows the same type of displacement, namely downthrow on the west side. Thus, in the southern part of the Sacramento Mountains the strata are uplifted along two fault zones, and there is an asymmetrical trough formed by the back slope of the lower fault block and the steep escarpment of the higher one.

The capping rock over most of the range is the San Andres limestone (Permian—Guadalupe), which ranges in thickness from a feather edge to a maximum of 700 ft. The San Andres is underlain by less resistant mudstone, gypsum, and thin-bedded limestone of the Yeso formation (Permian—Leonard), 1,200 to 1,800 ft thick, and this in turn by redbeds of the Abo formation (Permian—Wolfcamp) and successively older strata down to Precambrian(?). The strata dip eastward at about 100 ft per mile.

The stratigraphy and structure of the Sacramento Mountain front have been summarized by Pray (1954).

TOPOGRAPHY

The escarpment that faces the Tularosa Basin has been much dissected by streams in short steep canyons. In the northern and central part of the range, these streams are actively shifting the divide eastward, at the expense of streams flowing down the long gentle back slope of the mountains to the Pecos River some 80 miles to the east. In the southern part, a three-way drainage system has developed (fig. 2), owing to the structural trough in front of the Sacramento River fault zone. The components of this three-way system are (1) the short, steep-gradient streams, such as Grapevine Canyon and its tributaries, that flow into

the Tularosa Basin and end on alluvial fans; (2) the Sacramento River, flowing southeastward and also ending on an alluvial fan; and (3) the upper reaches of many streams that flow eastward to the Pecos River.

All these, including the Sacramento "River," are ephemeral streams. The present climate is semi-arid; average annual precipitation at Cloudcroft is 22.0 in., and that at Alamogordo is 10.5 in. Spring runoff from melting snow may put some water into stream channels over most of the range, and summer rainstorms may produce heavy discharge locally and temporarily. For the sake of brevity,

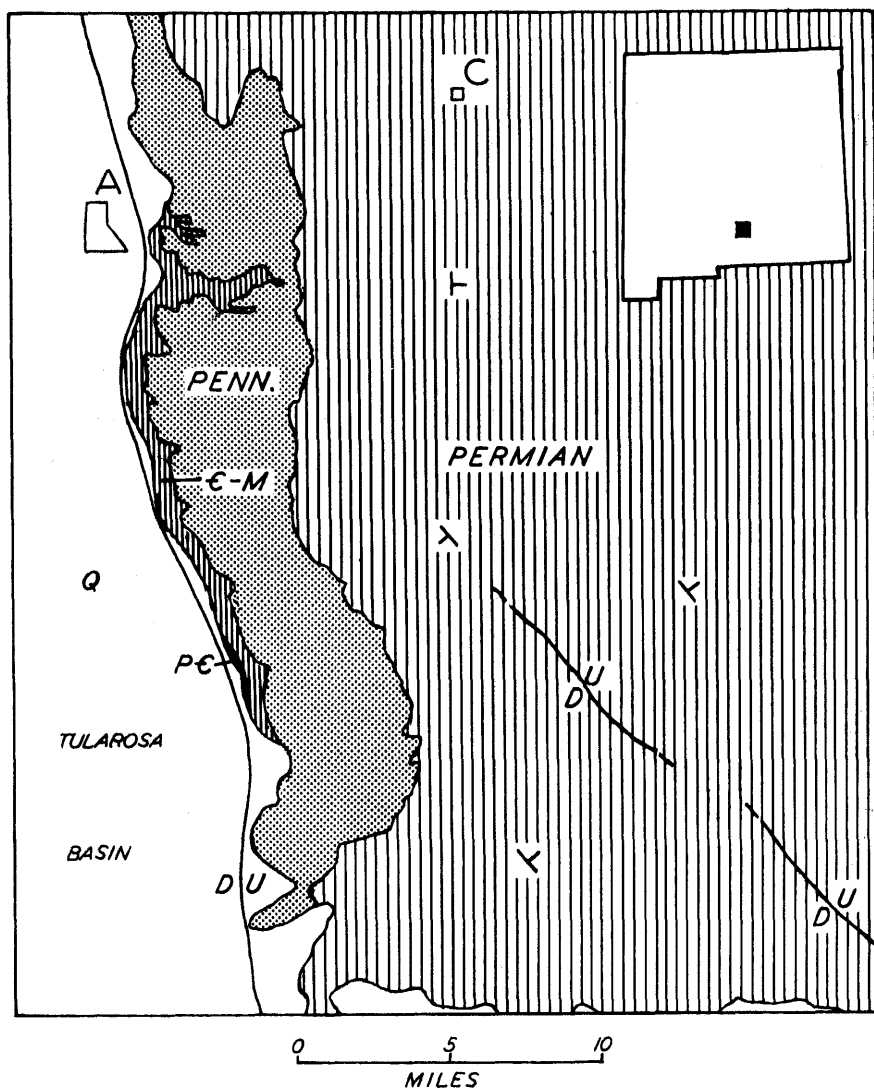


FIGURE 1. Generalized geologic map of the Sacramento Mountains, New Mexico. Elevation of Cloudcroft (C) at crest of the range is 8,650 ft; that of Alamogordo (A) is 4,300 ft.

in this paper a term such as "Grapevine Canyon" is used to refer both to the canyon and to the ephemeral stream that flows in it.

A drainage map of the southern part of the range (fig. 3) shows the extent to which the three components of the drainage are out of adjustment. Tributaries entering the Sacramento River from the west are being captured by streams flowing into the Tularosa Basin, and indeed at places the main river channel itself is threatened. Eastern tributaries of the Sacramento, on the other hand, are growing by capture of the headwaters of Pecos River drainage. The asymmetry of the Sacramento River valley is shown on the profile, figure 4.

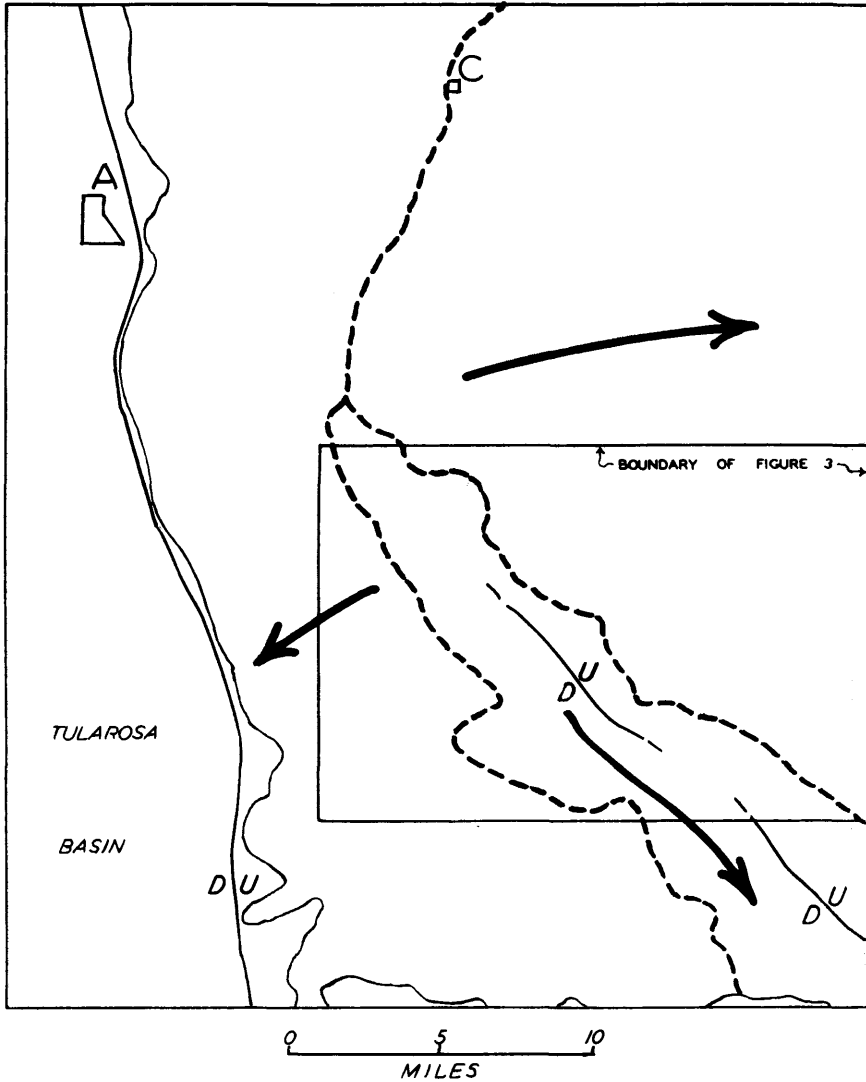


FIGURE 2. Three-way drainage pattern of the Sacramento Mountains. Dashed lines are divides.

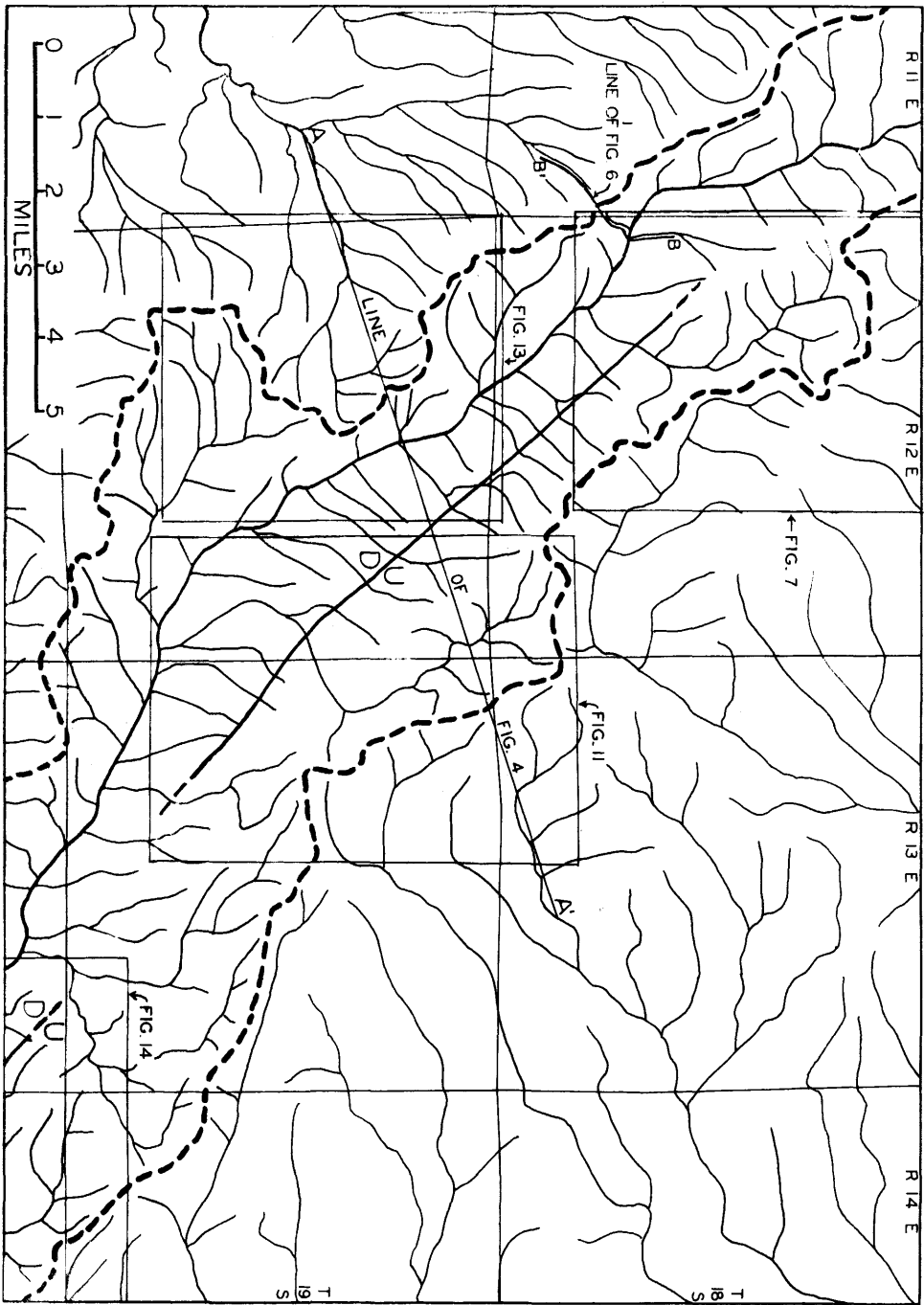


FIGURE 3. Drainage and index map, southern Sacramento Mountains. See figure 2 for location of the area.

MAP AND PHOTOGRAPH COVERAGE

Most of the area considered lies within the Sacramento Division of the Lincoln National Forest, for which a modern topographic contour map is available. In addition, the eastern part of the area is covered by air photographs made by the Soil Conservation Service in 1941 and 1942. The photo coverage extends for some distance south of the mapped area. No controlled photo-mosaics or large-scale geologic maps are known to me. The area is shown on a recent preliminary geologic map of southeastern New Mexico (Dane and Bachman, 1958), on a scale of one inch to about 6 miles.

DRAINAGE DEVELOPMENT
Grapevine Canyon—Sacramento River

Capture of the upper course of the Sacramento River by tributaries of Grapevine Canyon is imminent. Maps and air photographs of the divide show that

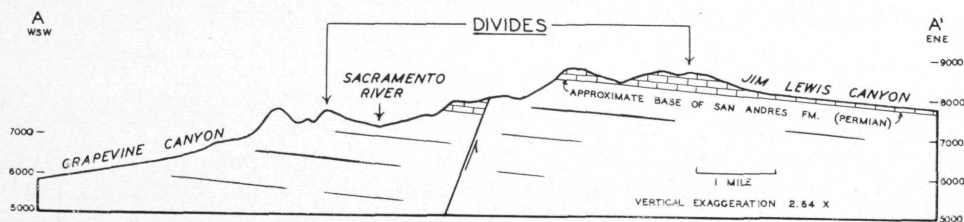


FIGURE 4. Profile, southern Sacramento Mountains, along line A-A', figure 3. Note asymmetry of the Sacramento River valley.

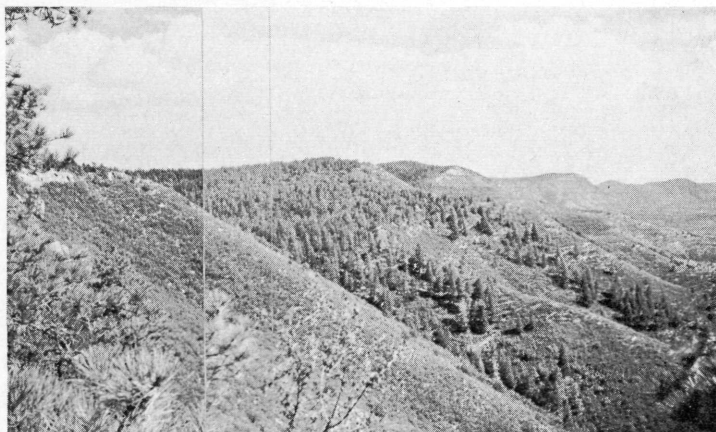


FIGURE 5. View southeastward along escarpment in sec. 25, T. 18 S., R. 11 E., near where West Side Road crosses the divide. Steep slope, underlain by soft rocks of Yesso formation, drains west into Grapevine Canyon. Skyline to left of center marks approximate dip slope on the San Andres limestone, draining into Sacramento River.

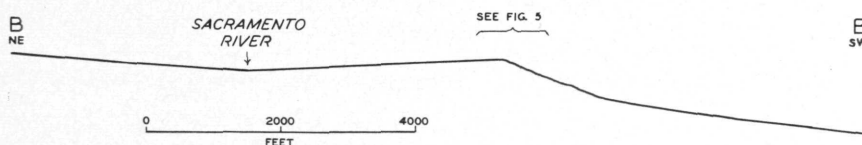


FIGURE 6. Profile along line B-B', figure 3. Horizontal and vertical scales are the same. By headward erosion, tributaries of Grapevine Canyon on the right will eventually reach and divert the Sacramento River.

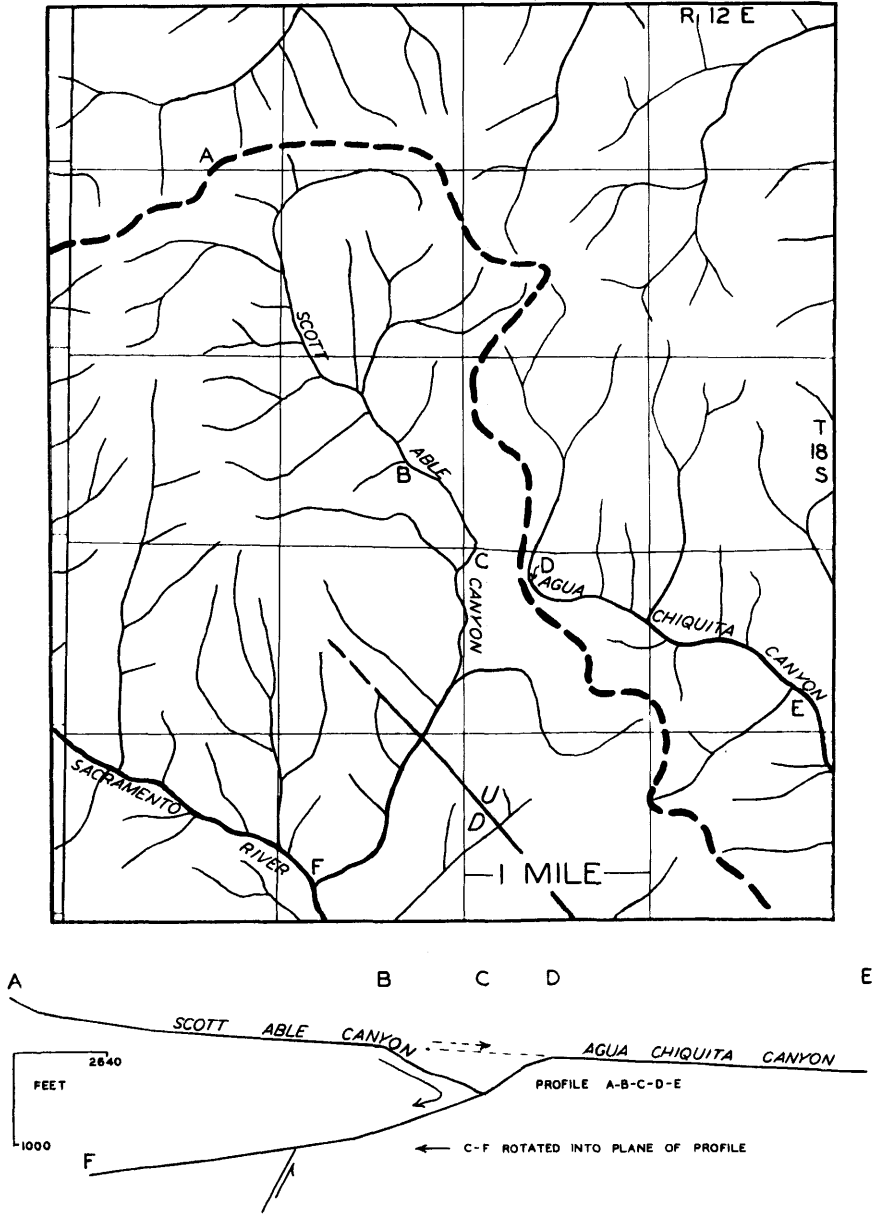


FIGURE 7. Recent beheading of Agua Chiquita Canyon by Scott Able Canyon. See figure 3 for location of the area. Photographs shown in figures 8, 9, and 10 were taken at point D on the map.



FIGURE 8. View southeast down the floor of Agua Chiquita Canyon at point D on figure 7. This is typical of the valleys that drain eastward to the Pecos River.

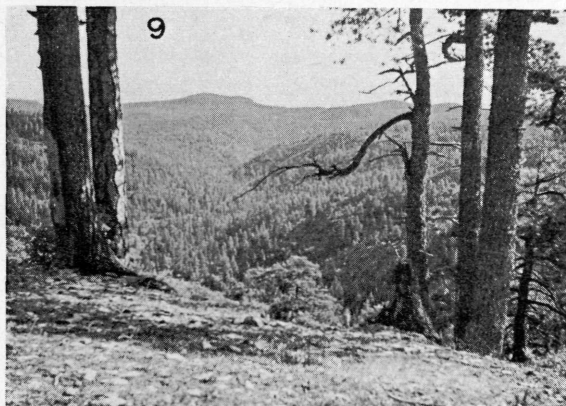


FIGURE 9. View southwest, from same point as figure 8, down Scott Able Canyon. In foreground is floor of beheaded Agua Chiquita Canyon, with gravel of San Andres limestone, the bedrock formation.

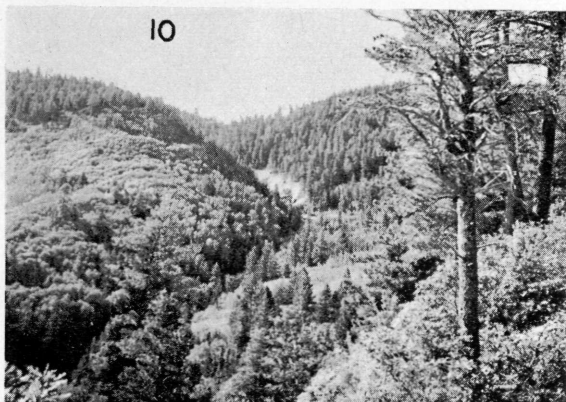


FIGURE 10. View northwest, up Scott Able Canyon, from a point a few feet west of where figures 8 and 9 were taken.

capture will first occur in the southeastern part of T. 18 S., R. 11 E. (fig. 3), where the divide is only 0.7 mile horizontally and 200 ft vertically from the bed of the river. A photograph of the escarpment at this place is given in figure 5, and a profile in figure 6. Since Grapevine Canyon falls more than 600 ft in the first mile west of the divide, and is eroding weak rocks of the Yesso formation, rapid headward encroachment to the river channel is inevitable. Although the river is under attack from west-flowing streams at other places along its course, nowhere else is the stage set for such early action.

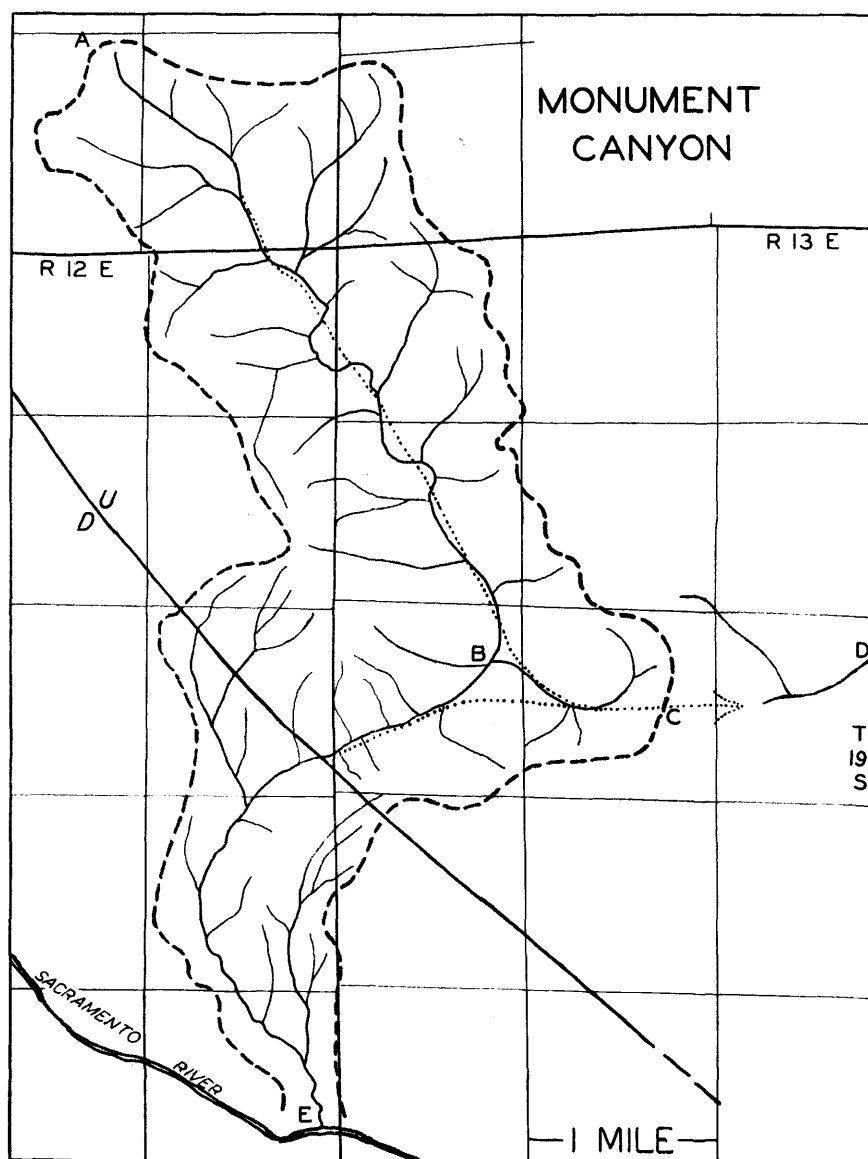


FIGURE 11. Drainage basin of Monument Canyon. Dotted lines show approximate course before capture. Letters refer to the profile, figure 12. See figure 3 for location of the area.

Unlike many parts of the southern Sacramento Mountains, the locality mentioned above is readily reached by car. A gravel road, known as the West Side Road, which follows a tortuous route from near Cloudcroft southward along the mountain front for many miles, climbs the escarpment here and crosses the divide into the Sacramento River valley.

Scott Able Canyon—Agua Chiquita Canyon

The type of diversion predicted above has already occurred at a number of places. The most striking example, because the most recent, is the interception of Agua Chiquita Canyon by Scott Able Canyon, a tributary of the Sacramento River (fig. 7). Here, as elsewhere, downcutting by the capturing stream has been facilitated because it is eroding in soft rocks of the Yeso formation, below a thin capping of San Andres limestone on which the captured stream takes its course.

The recency of this event is shown by the concordance between the long profile of upper Scott Able Canyon and that of Agua Chiquita Canyon (fig. 7), and also by the field relations. A natural vantage point is the jumping-off place where the present divide crosses the floor of Agua Chiquita Canyon some 400 ft above the elbow of capture. (This point can be reached by a primitive Forest Service road.) To the southeast, one views the wide gently sloping canyon of the beheaded stream (fig. 8). Turning to the southwest, one looks out over the gorge of Scott Able Canyon (fig. 9). By moving a few feet out to the very rim,

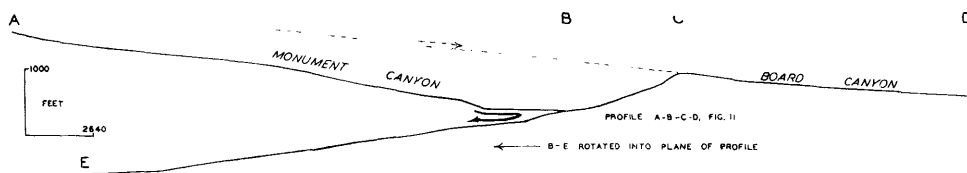


FIGURE 12. Beheading of Board Canyon by Monument Canyon. See map, figure 11, for letters locating profile.

one may then look upstream into that part of Scott Able Canyon that has a gradient of nearly 1,000 ft per mile (fig. 10). A more remarkable example of just-completed stream diversion would be hard to find.

Monument Canyon—Board Canyon

Monument Canyon, the next major stream course to the southeast, has had a similar history, although capture evidently occurred less recently. A map of its drainage basin (fig. 11) shows that the upper three-fifths of the present Monument Canyon formerly constituted the headwaters of Board Canyon, a stream of gentle gradient flowing eastward toward the Pecos River. The capturing stream has had time to steepen the gradient of the diverted segment of Board Canyon (fig. 12), and also to push back the divide east of the elbow of capture. The hooked stream pattern in sec. 17, T. 19 S., R. 13 E., suggests that the west-flowing tributary of Monument Canyon is now capturing and reversing the main channel of Board Canyon, barbing its tributaries.

Grapevine Canyon—Arkansas Canyon

A sequence of events markedly similar to that just described is shown by map and profile (fig. 13) to have occurred along the lower escarpment, southwest of the Sacramento River. Arkansas Canyon, a tributary of the river, has been beheaded by Grapevine Canyon, and the ensuing time has been long enough to allow the latter to deepen the valley of the captured stream for more than a mile above the elbow of capture.

In this area the headwaters of Grapevine Canyon are as close to the main channel of the Sacramento River as they are in T. 18 S., R. 11 E., described in an earlier paragraph. Here, however, the gradient of Grapevine Canyon is less

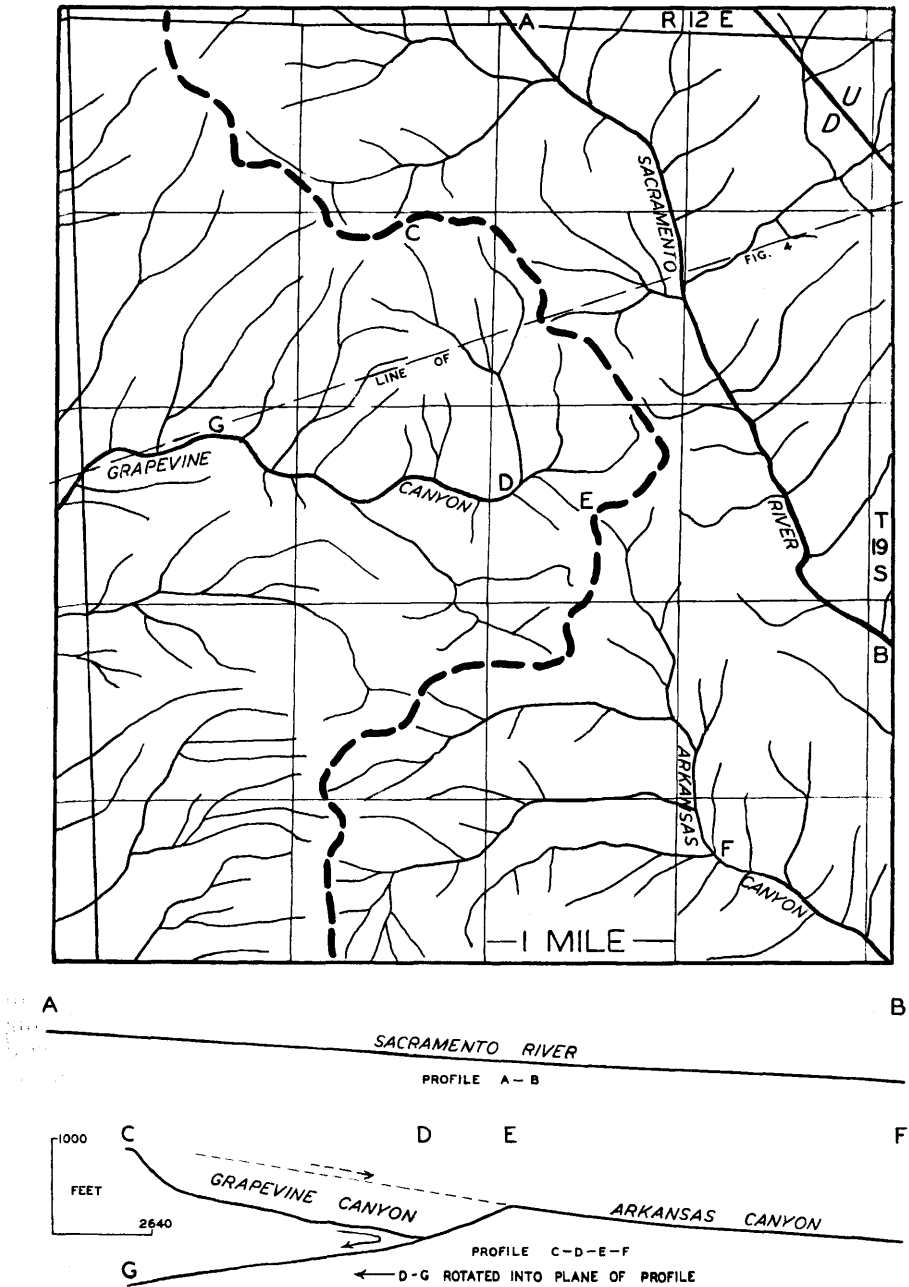


FIGURE 13. Beheading of Arkansas Canyon by Grapevine Canyon, and headward encroachment of the latter toward channel of the Sacramento River. See figure 3 for location of the area.

steep, and capture of the main stream will probably be deferred until after it has taken place in the other area.

The beheading of Arkansas Canyon can be taken as a preview of events to come for the Sacramento River.

Surveyors Canyon

In the southeastern part of the area shown on figure 3, and for some distance farther southeast beyond map control, there is a series of canyons that show a somewhat different history. Typical is Surveyors Canyon (fig. 14), a high-gradient tributary of the Sacramento River which has worked headward across the Sacramento River fault zone and diverted a stream system that formerly flowed east. Diversion has been accomplished by the wholesale reversal of the former stream course, with production of a notable set of barbed tributaries. It was while doing plane-table work in the Surveyors Canyon area that I first became aware of the anomalous stream patterns to be encountered in the southern Sacramentos.

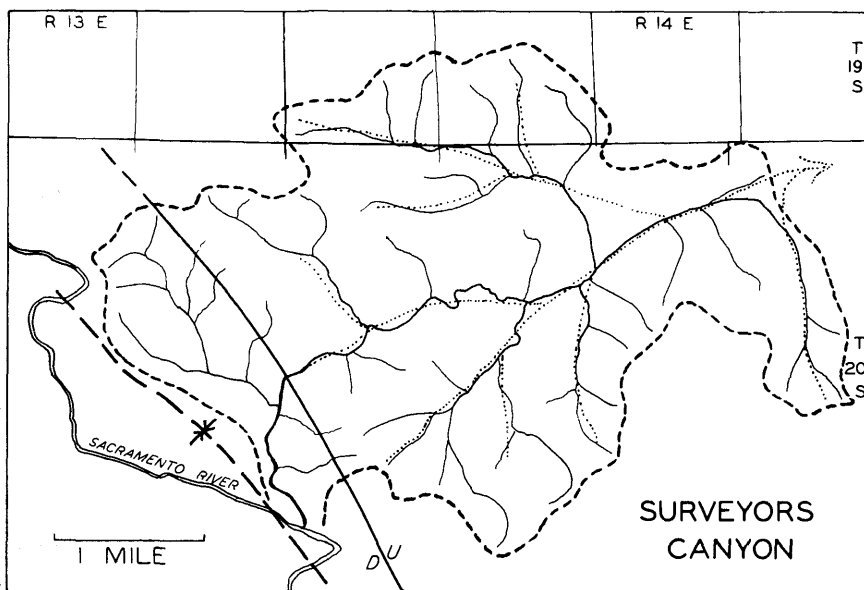


FIGURE 14. Drainage basin of Surveyors Canyon. Dotted lines show approximate course before reversal. See figure 3 for location of the area. The part lying in T. 20 S. has been traced from air-photograph contact prints.

Probably this type of diversion resulted from the fact that the stream to be captured was flowing almost directly away from the capturing stream, rather than at a pronounced angle to it. In this back-to-back relationship, the advantage was with the steep-gradient tributary of the Sacramento River.

EVOLUTION OF THE DRAINAGE

The present drainage pattern of the southern Sacramento Mountains is clearly structure-controlled. The streams are where they are because of uplift along the normal-fault zones and concurrent tilting of the strata. The anomalous stream patterns, and the youthful stage of development of the canyons, show that the streams have made only a start toward adjustment to structure.

Yet surely there could be few geologic situations in which stream adjustment could proceed faster than here. Not only do the potential capturing streams have the advantage of steep gradients, but they are eroding in weakly resistant rocks; while their prey, the Sacramento River and the east-flowing streams on the back slope of the range, are flowing on a thin veneer of San Andres limestone which is vulnerable to erosive attack along sharp divides. That even under these circumstances the drainage system is still so far from equilibrium strongly suggests that it is of very recent origin.

Two additional lines of evidence, one geomorphic and the other structural, support this conclusion. According to Pray (1954, p. 105), the Sacramento Mountains are bevelled by a widespread surface of erosion or summit peneplain. As evidence of the youthfulness of this surface, Pray and Allen (1956) cite the discovery of a small Cretaceous outlier at the crest of the northern part of the range. The strata of this outlier are about 200 ft thick, carry a Dakota(?) fauna, and rest on the San Andres limestone. They dip about 10 degrees, and lie well below the restored level of the summit peneplain. Thus, the latter must be post-Dakota. Pray and Allen conclude that it is Cenozoic, probably late Cenozoic.

Regional structural and stratigraphic evidence indicates that the normal faulting of the range took place during the Cenozoic, as did that in the other block mountains of the Basin and Range province. Indeed, little fault scarps that cut the alluvial fans along the west base of the range show that faulting has continued essentially to the present. Thus, it seems quite clear that peneplanation, uplift, and drainage development are all very recent events, probably occurring entirely in the late Cenozoic.

The general pattern of future evolution seems plain. The Sacramento River will be diverted to the west, and the lower escarpment will cease to exist as a major divide. All drainage will flow either west into the Tularosa Basin or eastward to the Pecos River. Although the west-flowing streams will be aggrading their lower courses by the further build-up of alluvial fans, still they will have steeper gradients than their opposite numbers for a long time to come. Hence the remaining divide will be shifted eastward, and the mountain profile will gradually approach symmetry. Any renewed uplift on the faults of the range will increase the gradients of all the streams, speed up the removal of the thin capping sheet of San Andres limestone, help obliterate the Sacramento River valley, and aid in establishing a bilateral system of drainage.

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